



Formula of a Hydrate

Topical Unit of Instruction: Chemical Formulas or Liquids and Solids

Introduction

No toxic materials are used in this lab. Both chemicals, alum and Epsom salts, are available in your local drug store. Alum is commonly used in home pickling (Check out the ingredients on your pickle relish jar in your refrigerator at home!) and Epsom salts are frequently used in solution to soak sprained ankles or wrists. Perhaps some of your students will be familiar with Epsom salts. Both alum and Epsom salts can be ordered from a science supply vendor as well.

Time

50 minutes to collect data

30 minutes to process data

Objectives

1. To determine the formula of a hydrate.
2. To calculate the percent H_2O in a hydrate.

Preparation

Assign each lab pair one of the hydrates. If you have plenty of evaporating dishes and crucibles with covers, you may just want to assign alum to half the class and Epsom salts to the other half.

Safety Reminders

1. Porcelain retains heat for a prolonged period of time so cooling requires many minutes. Remind students to be very careful not to burn themselves.
2. Remind students never to set hot porcelain on the lab countertop.
3. Students should not peer over "cooking" hydrates to avoid steam burns as water is released.

Typical Results and Calculation Tips

1. Subtract mass of empty dish (a) from mass of dish and anhydrous salt (c).

2. Molar masses:



$$\text{Al: } 1 \times 27.0 = 27.0$$

$$\text{K: } 1 \times 39.1 = 39.1$$

$$\text{S: } 2 \times 32.1 = 64.2$$

$$\text{O: } 8 \times 16.0 = 128.0$$

$$258.3$$



$$\text{Mg: } 1 \times 24.3 = 24.3$$

$$\text{S: } 1 \times 32.1 = 32.1$$

$$\text{O: } 4 \times 16.0 = 64.0$$

$$120.4$$

3. Divide g (#1 above) by molar mass (#2 above).

Materials

(For a class of 32 students working in pairs)

- 16 porcelain containers-mixture of evaporating dishes and crucibles with covers
- 16 wire gauze or pipe stem triangles to accommodate evaporating dish/crucible assortment
- alum
- Epsom salts
- 16 crucible tongs
- balances
- 16 ring stands
- 16 iron rings
- 16 laboratory burners
- 16 burner lighters



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(continued from front side)

4. Subtract mass of dish and anhydrous salt (c) from mass of dish and hydrate (b).

5. Molar mass H_2O :

$$\begin{array}{rcl} \text{H: } 2 \times 1.0 & = & 2.0 \\ \text{O: } 1 \times 16.0 & = & 16.0 \\ & & 18.0 \end{array}$$

6. Divide g of H_2O (#4 above) by molar mass of H_2O (#5 above).

7. Alum should be 12; epsom salts should be 7.

8. Alum is $\text{AlK}(\text{SO}_4)_2 \cdot 12 \text{H}_2\text{O}$

Epsom salts is $\text{MgSO}_4 \cdot 7 \text{H}_2\text{O}$

9. Alum:

$$\begin{array}{rcl} \text{Al: } 1 \times 27.0 & = & 27.0 \\ \text{K: } 1 \times 39.1 & = & 39.1 \\ \text{S: } 2 \times 32.1 & = & 64.2 \\ \text{O: } 8 \times 16.0 & = & 128.0 \\ \text{H}_2\text{O: } 12 \times 18.0 & = & 216.0 \\ & & 474.3 \end{array}$$

Epsom Salts:

$$\begin{array}{rcl} \text{Mg: } 1 \times 24.3 & = & 24.3 \\ \text{S: } 1 \times 32.1 & = & 32.1 \\ \text{O: } 4 \times 16.0 & = & 64.0 \\ \text{H}_2\text{O: } 7 \times 18.0 & = & 126.0 \\ & & 246.4 \end{array}$$

$$\% \text{H}_2\text{O} = (216.0 / 474.3) \times 100\% = 45.5\% \text{ (almost half!)} \quad \% \text{H}_2\text{O} = (126.0 / 246.4) \times 100\% = 51.1\% \text{ (over half!)}$$

Disposal

Wrap anhydrous salts in paper towels and place in garbage. You could also collect the dehydrated alum and Epsom salts in separate containers and rehydrate them with very large amounts of distilled H_2O . It will take several months for the excess H_2O to evaporate, and the student results may not be quite as good as with “new” hydrates if you attempt to use the “rehydrates” the following year.

Hints

1. If time is a factor in data collection, students may wish to carefully set the hot porcelain container on the iron base of the ring stand (not the countertop!) with tongs. It will cool more quickly.
2. The iron rings will remain hot for many minutes. Rather than risk the students burning themselves, it may be easier for you to put the rings and stands away several hours after students have completed the lab.

